Ocean Dynamics: IWISE DRI

Robert Pinkel
Marine Physical Laboratory
Scripps Institution of Oceanography
La Jolla, California 92093-0213
Phone: (858) 534-2056 fax: (858) 534-7132 email: rpinkel@ucsd.edu

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LONG-TERM GOALS

To gain a more complete understanding of ocean dynamical processes, particularly at fine-scale, through comparison of high, mid- and low-latitude observations, near the sea surface, in the main thermocline, and near the sea floor.

OBJECTIVES

To identify the phenomena involved in the cascade of energy from meso-scales to turbulent scales. In particular, we wish to quantify the relationship between fine-scale background conditions and the occurrence of microscale breaking.

APPROACH

Progress is achieved through a steady-state cycle of instrument development, field observation and data analysis. The primary instruments employed include Doppler sonar, rapidly-profiling CTD's, and Wirewalker ocean-wave-powered vertically-profiling floats. Our instruments produce information that is quasi-continuous in space and time, typically spanning two decades in the wavenumber domain. This broad band space-time coverage enables the investigation of multi-scale interactions.

WORK COMPLETED

Our major accomplishments include participation in the Summer 2011 IWISE cruise to Luzon Strait and the Heng Chun Ridge on the RV Revelle. We focused on the development of deep-ocean turbulence in an outflow channel in Luzon Strait, (Fig 1a, b) where numerical simulations suggested energetic turbulence would be present. We employed the MPL-SIO Fast CTD (Fig 1b) to study the phenomenon, along with the HDSS sonars on the Revelle. The systems performed well for the duration of the experiment. Over 800 CTD profiles were collected, to depths as great as 1900 m (Fig 2).

On May 2013, we revisited the Luzon Strait to continue study of the North Outflow Channel. This time we continuously transited the channel, taking observations along the channel-axis as the flow evolved through the tidal cycle. Very large lee-waves and mixing events were again seen, although the striking sea surface signature of the lee-waves was absent.

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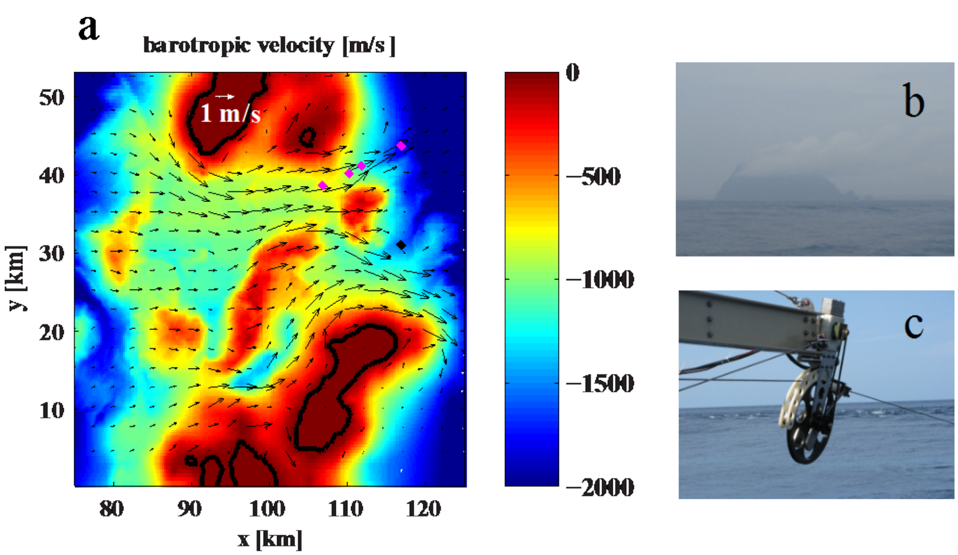

Figure 1. a. A topographic map of central Luzon Strait showing barotropic tidal flow vectors from the MIT cgm. Magenta dots show the location of stations in the North Outflow Channel of the Ridge. b. Proximity to local islands rendered ship maneuvering difficult. c. The motorized sheave on the Fast CTD. In the background is the surface disturbance caused by the internal lee-waves.

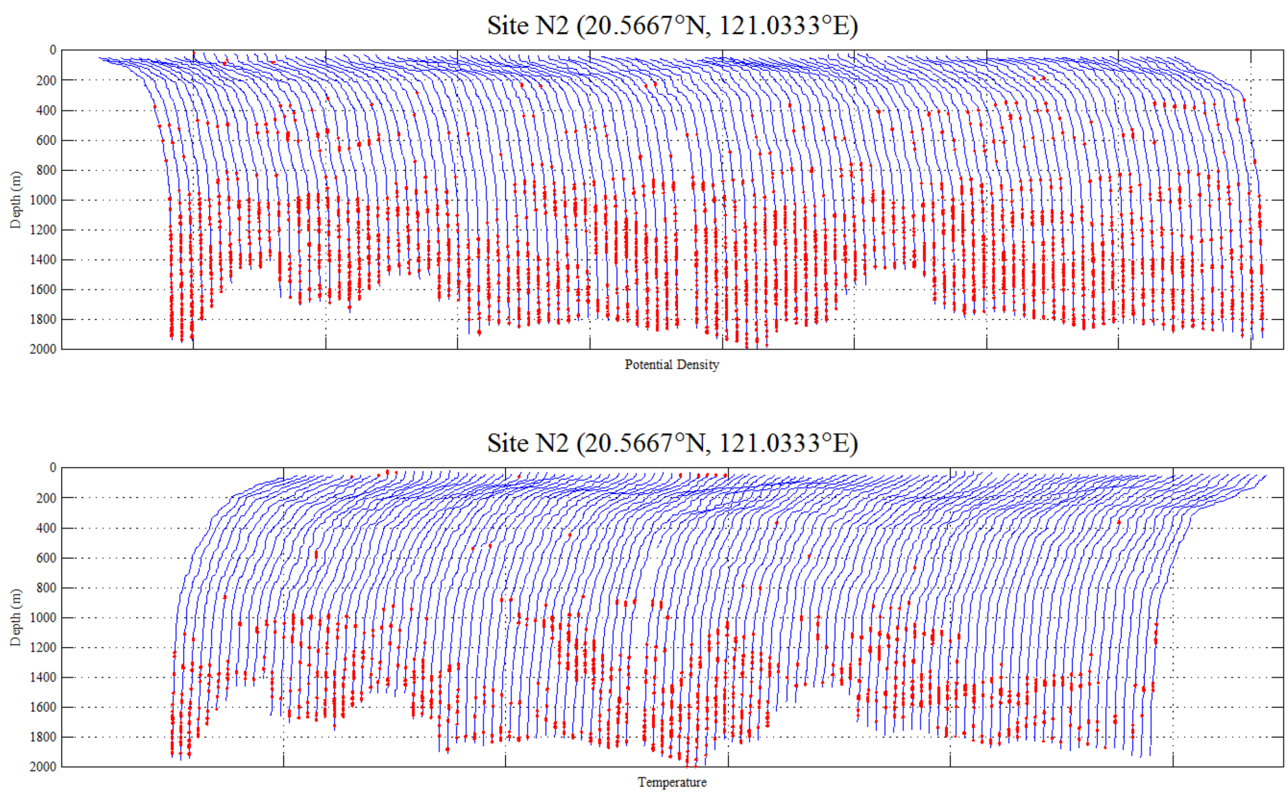

Figure 2. A sample of the real-time display from the Fast-CTD at site N2, on the eastern flank of the Heng Chun Ridge. Density profiles to ~1800 m were repeated every 20 minutes. Red dots indicate overturns in the density field (top) and temperature field (bottom). During periods of eastward flow, significant mixing was observed ~1000 m above the topography.

RESULTS

It was found that mixing is associated with a variety of flow phenomena in the outflow channel, Fig.3. Thanks to the establishment of a complex lee wave pattern, mixing is not confined to the "near bottom" region. The full water column feels the effect of the 1000 m deep topography. Depth-integrated mixing rates approach 8 Watts/m^2, perhaps the highest deep-sea values recorded to-date.

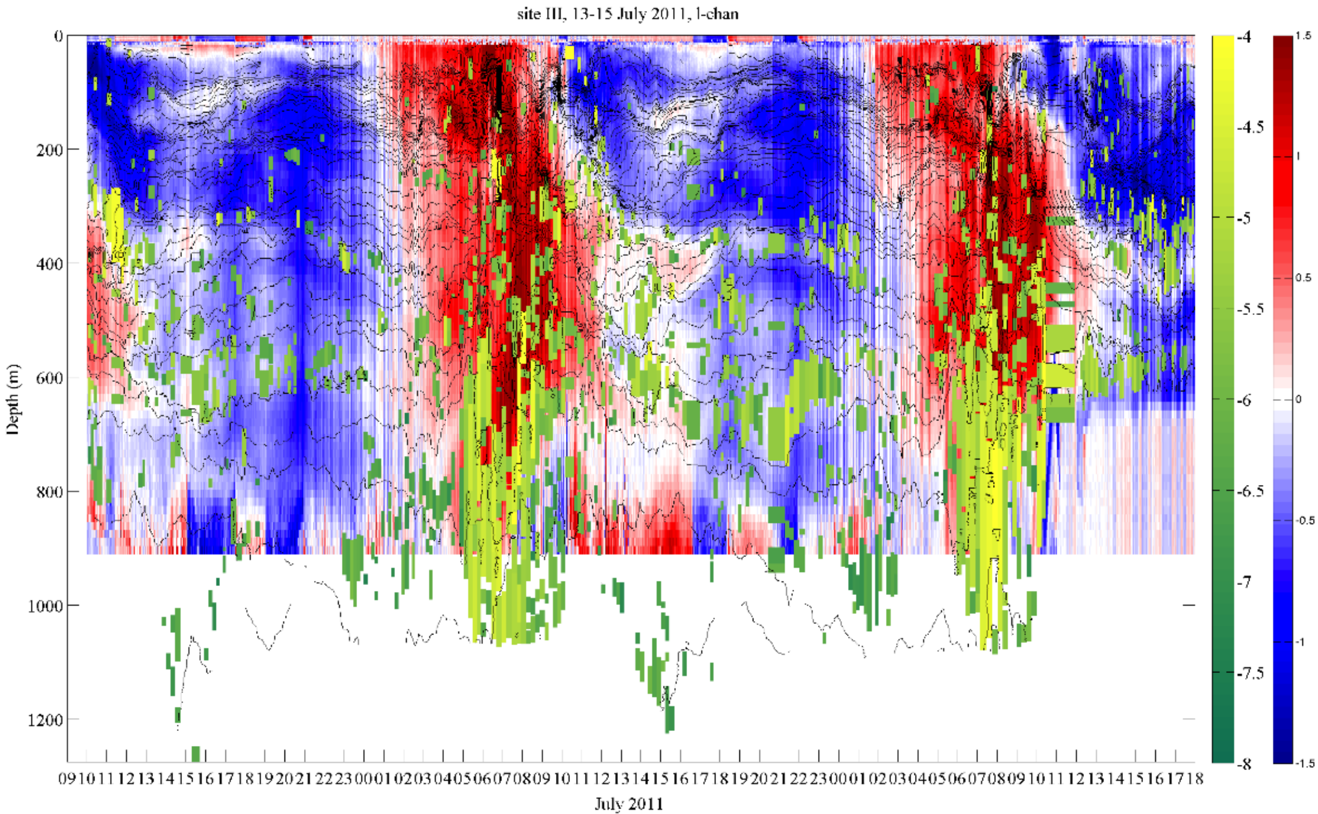

Figure 3. Along-channel flow and isopycnal vertical displacement at Site III in the North Outflow Channel. Green dots indicate sites of overturning, which is concentrated in periods of eastward tidal flow.

IMPACT/APPLICATIONS

In 2011, the lee wave generated in the Luzon outflow channel was sufficiently strong to modify the propagation of sea surface waves, more that 1000m above the topography (Fig 1c). This is perhaps the first example of a surface signature of deep topography NOT associated with propagating solitary waves.

TRANSITIONS

We have successfully recruited Ms. Ruth Musgrave, an extremely promising SIO student, to work on data and modeling aspects of the IWISE 2011 data and the 2013 observations. Ruth participated in the collection of the 2013 data. She is co-advised by Profs Jen MacKinnon and R. Pinkel.

RELATED PROJECTS

Follow-on work in the South China Sea will focus on sub-mesoscale processes, as an aspect of the Vietnam DRI (January 2014) and the coming Sub-Mesoscale DRI.

PUBLICATIONS

Klymak, J.M., S. Legg, M.H. Alford, M. Buijsman, R. Pinkel, and J.D. Nash. 2012 The direct breaking of internal waves at steep topography. Oceanography, 25-2,150-160.

Pinkel, R., M.Buijsman and J.M. Klymak. Breaking topographic lee waves in a tidal channel in Luzon Strait. Oceanography, 25-2, 160-166.